Clinical Science – Medical Physics and Bioinformatics

University Hospitals Birmingham NHS Foundation Trust

Gavin Kirby, PhD — gavin.kirby@uhb.nhs.uk

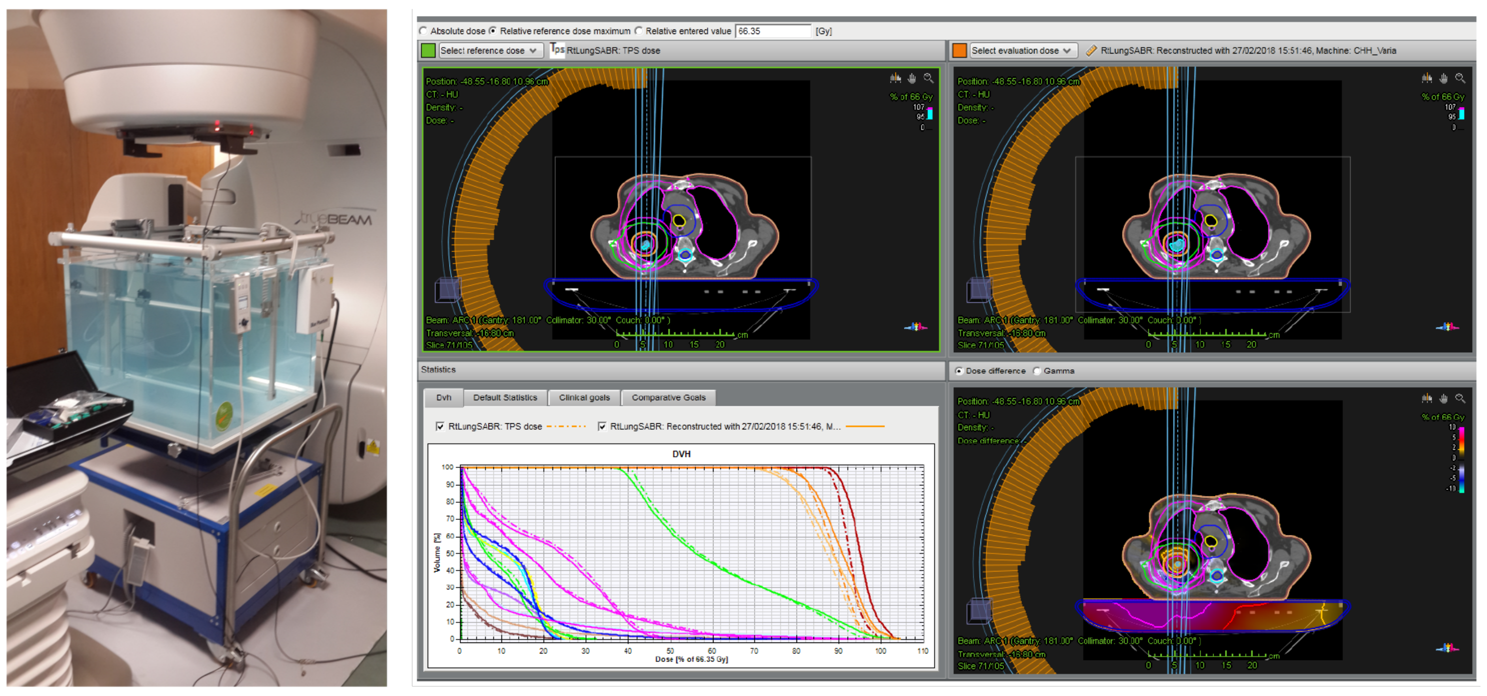
LGBT STEM

Clinical science – use scientific knowledge for tangible benefit

- Broadly: *applied science for patient benefit*.
- Basic rôle of a clinical scientist comprises:
  - Quality assurance of equipment.
  - Auditing to ensure compliance with legislation & best practice guidelines.
  - Translational research & service development.
  - Providing scientific advice to clinical services.
  - Teaching & training of scientists, physicians, and technologists.

Clinical radiotherapy physics – routine work

- Broad specialism within medical physics.
- Radiation dosimetry and treatment planning.
- External-beam X-ray and electron therapies, and brachytherapy.
- Important intersection with radiology (CT & MR).



Using a water tank phantom for relative dosimetry during linac commissioning (L); a gamma analysis is performed to assess a treatment machine's delivery of a lung treatment plan against the treatment-planning system prediction (R).

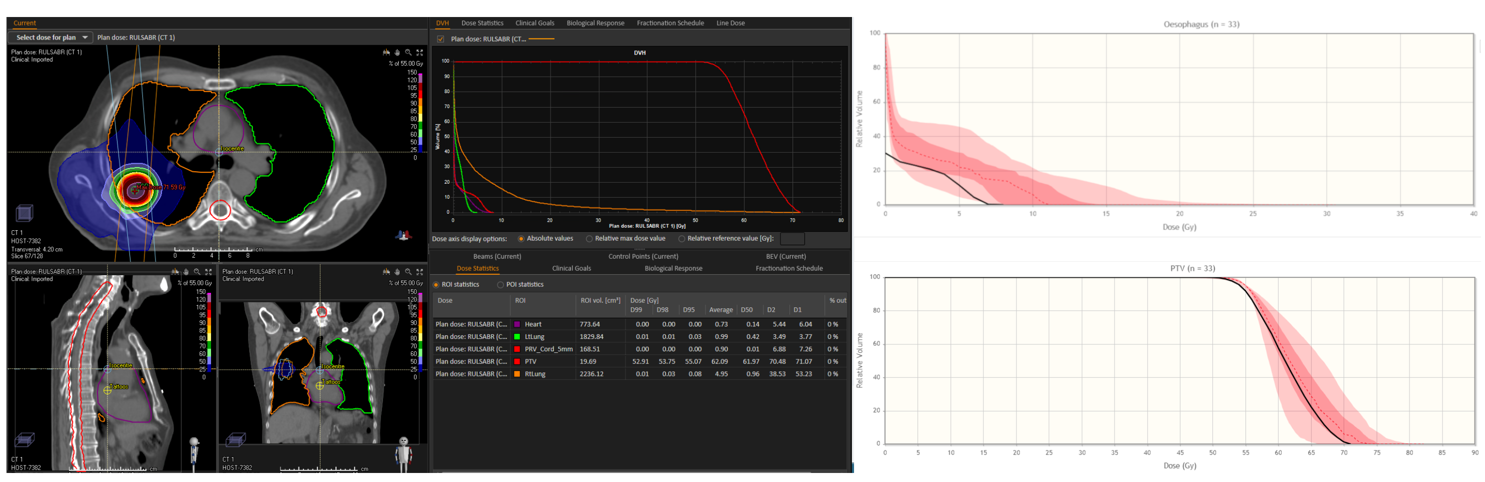
Bioinformatics in the physical sciences

- Broadly: *intersection of scientific computing and life sciences*.
- Medical physics depends heavily on computing – *e.g.* calculation of radiation doses, image quality optimisation, and optimisation of treatment plans.
- Computing essential for research and service development – data analysis and automation of workflow; commissioning of new software.
- In-house software development – bespoke, robust tools to satisfy departmental requirements & aid in meeting (inter)national guidelines.

Putting it together to develop the service

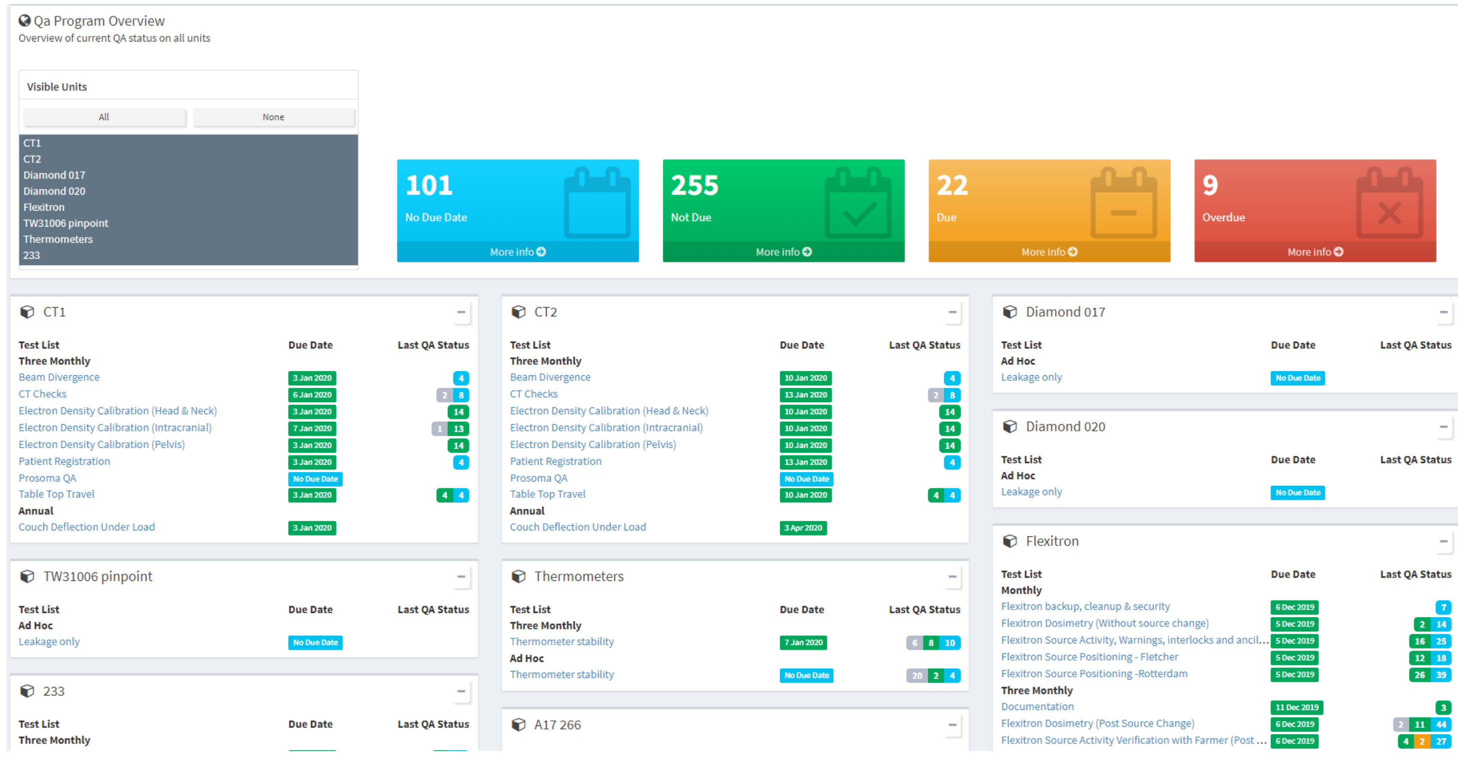
- Integrate developments in computing into clinical workflow.
- Transition to paperless/lite system → increased efficiency & safety.
- Dashboards for workflow visualisation and easy data exploration – existing commercial solutions do not provide such bespoke functionality in a single application. Facilitate auditing and service development.
- Scripting for treatment planning systems – automate routine tasks such as organ contouring and beam placement.

Knowledge-based planning: plan evaluation

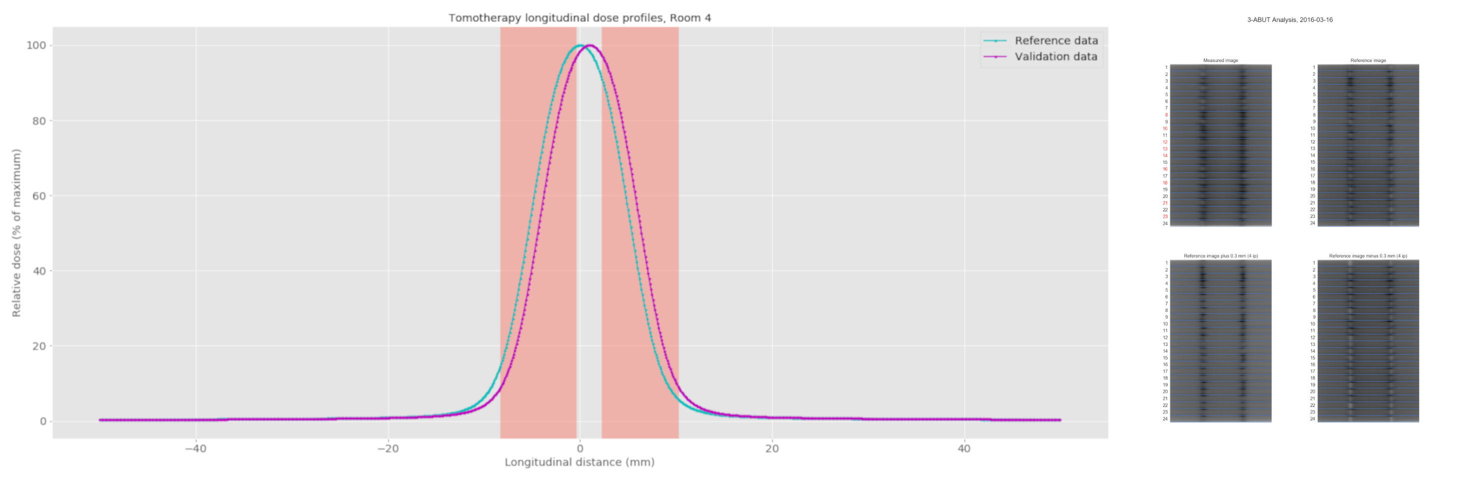


A dashboard application developed by the UHB clinical computing science group for comparison of dose-volume histogram data against a population of historical patients ("good" plans). Here, a lung plan (in the RayStation treatment planning system, L) is analysed in terms of organ-at-risk sparing (top R) and target coverage (bottom R).

QATrack+ – streamline and automate QA

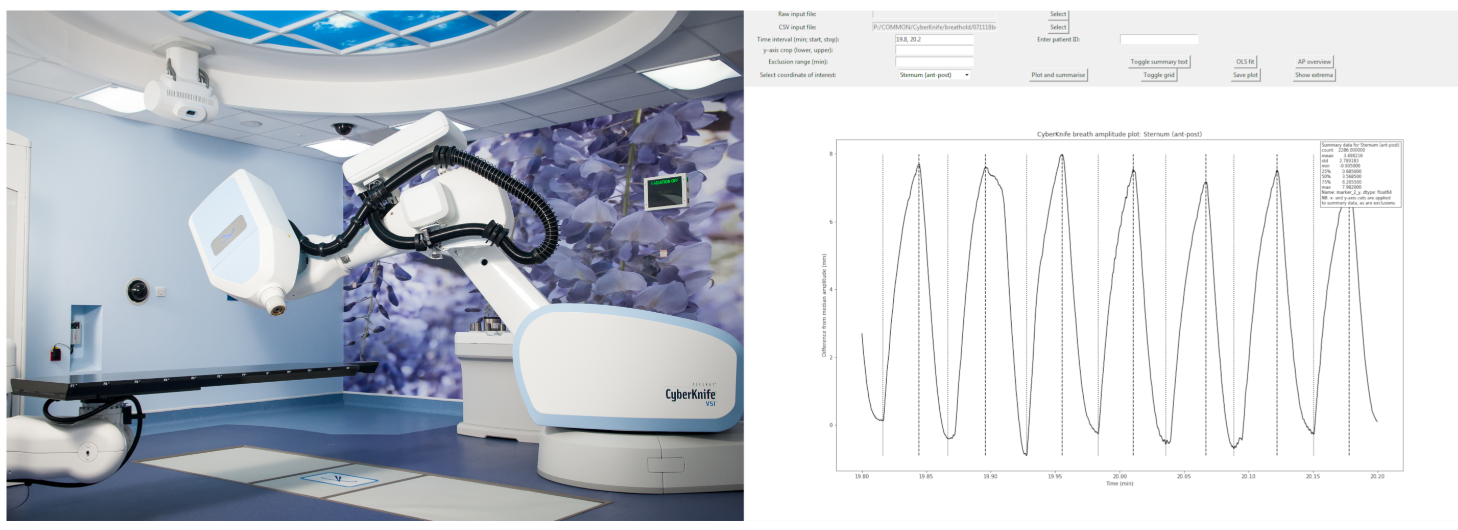


Project to commission QATrack+ and deploy it into routine practice – this software greatly facilitates the integration, scheduling, recording, and analysis of all departmental QA work. This is its overview dashboard, showing the current status of all machines.



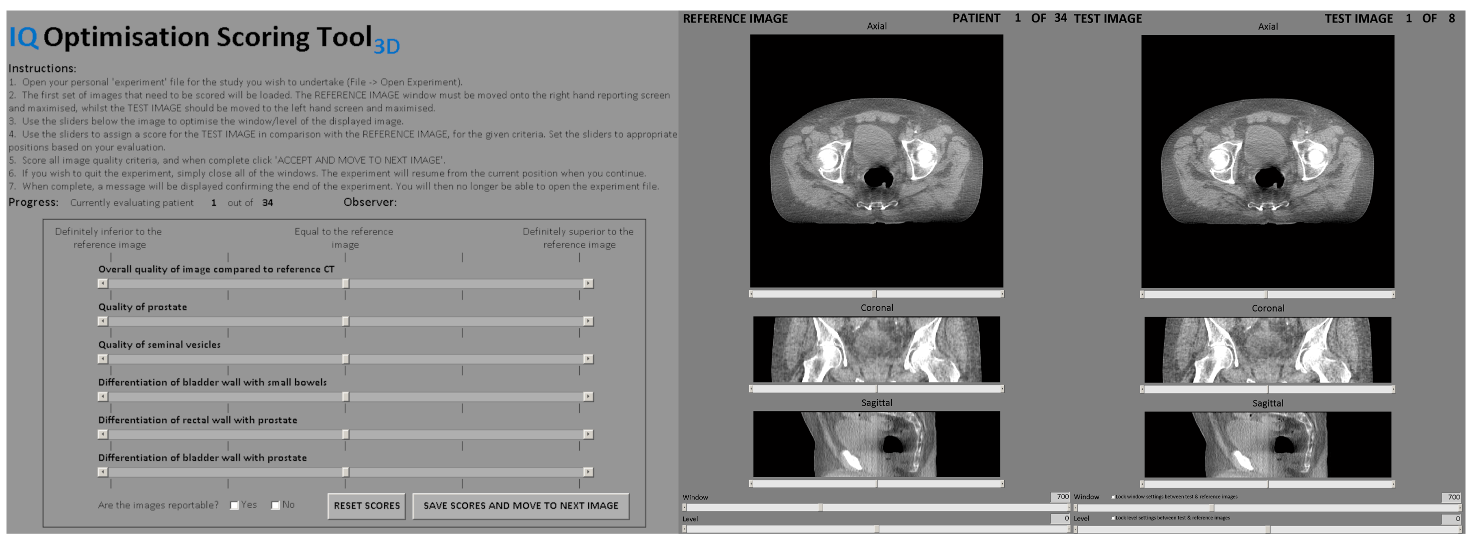
Automated QA – comparison of a measured photon beam profile against expected (L) and assessment of multileaf collimator leaf positions against their respective tolerances (3-abut analysis, R). Increased automation allows physicists to focus on non-routine work.

Research – CyberKnife patient respiratory motion analysis



CyberKnife is a high-precision radiosurgery unit used for treatments involving several small targets. A bespoke tool (R) was developed in Python for analysis of patient breathing positional data acquired using external fiducial markers.

Pre-treatment image optimisation



The MATLAB tool used to assess the subjective image quality of reconstructed pre-treatment cone-beam CT images.

- Aimed to compare images reconstructed using random variations on the reconstruction parameters to those using default values.
- Blinded radiographers scored each test image according to a set of predefined criteria.
- A linear mixed-effect regression model was fit to the data in R, to quantify the effect of varying each parameter independently.
- Phantom measurements with a range of X-ray tube voltages and currents → derivation of optimal exposure factors for a range of patient weight categories.